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House rats and mice.

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HOUSE RATS AND MICE

DAVID E. LANTZ

Assistant Biologist



FARMERS' BULLETIN 896

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Biological Survey

E. W. NELSON, Chief

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October, 1917

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THE RAT is the worst animal pest in the world.

From its home among filth it visits dwellings and storerooms to pollute and destroy human food.

It carries bubonic plague and many other diseases fatal to man and has been responsible for more untimely deaths among human beings than all the wars of history.

In the United States rats and mice each year destroy crops and other property valued at over \$200,000,000.

This destruction is equivalent to the gross earnings of an army of over 200,000 men.

On many a farm, if the grain eaten and wasted by rats and mice could be sold, the proceeds would more than pay all the farmer's taxes.

The common brown rat breeds 6 to 10 times a year and produces an average of 10 young at a litter. Young females breed when only three or four months old.

At this rate a pair of rats, breeding uninterruptedly and without deaths, would at the end of three years (18 generations) be increased to 359,709,482 individuals.

For centuries the world has been fighting rats without organization and at the same time has been feeding them and building for them fortresses for concealment. If we are to fight them on equal terms we must deny them food and hiding places. We must organize and unite to rid communities of these pests. The time to begin is now.

HOUSE RATS AND MICE.

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DESTRUCTIVE HABITS OF HOUSE RATS AND MICE.

LOSSES from depredations of house rats amount to many millions of dollars yearly—to more, in fact, than those from all other injurious mammals combined. The common house mouse¹ and the brown rat² (fig. 1), too familiar to need description, are pests in nearly all parts of the country; while two other kinds of house rats,

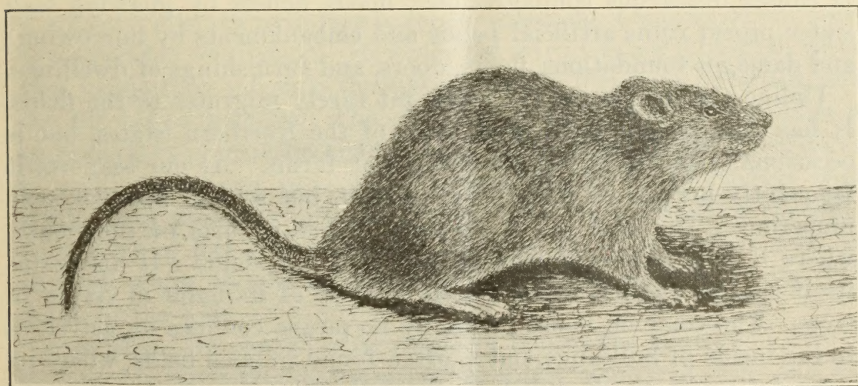


FIG. 1.—Brown rat.

known as the black rat³ and the roof rat,⁴ are found within our borders.

Of these four introduced species—for none is native to America—the brown rat is the most destructive, and, except the mouse, the most numerous and most widely distributed. Brought to America just

¹ *Mus musculus.*

² *Rattus norvegicus.*

³ *Rattus rattus rattus.*

⁴ *Rattus rattus alexandrinus.*

before the Revolution, it has supplanted and nearly exterminated its less robust relative the black rat; and in spite of the constant warfare of man has extended its range and steadily increased in numbers. Its dominance is due to its great fecundity and its ability to adapt itself to all sorts of surroundings. It breeds (in the middle part of the United States) six or more times a year and produces from 6 to 20 young (average 10) in a litter. Females breed when only 3 or 4 months old. Thus a pair, breeding uninterruptedly and without deaths, could in three years (18 generations) produce a posterity of 359,709,480 individuals. Mice and the black and roof rats produce smaller litters, but the period of gestation, about 21 days, and the number of litters are the same for all.

Rats and mice are practically omnivorous, feeding upon all kinds of animal and vegetable matter. The brown rat makes its home in the open field, the hedge row, and the river bank, as well as in stone walls, piers, and all kinds of buildings. It destroys grains when newly planted, while growing, and in the shock, stack, mow, crib, granary, mill, elevator, or ship's hold, and also in the bin and feed trough. It invades store and warehouse and destroys furs, laces, silks, carpets, leather goods, and groceries. It attacks fruits, vegetables, and meats in the markets, and destroys by pollution ten times as much as it actually eats. It destroys eggs and young poultry, and eats the eggs and young of song and game birds. It carries disease germs from house to house and bubonic plague from city to city. It causes disastrous conflagrations; floods houses by gnawing lead water pipes; ruins artificial ponds and embankments by burrowing; and damages foundations, floors, doors, and furnishings of dwellings.

Unlike the brown rat the black rat rarely migrates to the fields. It has disappeared from most parts of the Northern States, but is occasionally found in remote villages or farms. At our seaports it frequently arrives on ships from abroad, but seldom becomes very numerous. The roof rat is common in many parts of the South, where it is a persistent pest in cane and rice fields. It maintains itself against the brown rat partly because of its habit of living in trees. The common house mouse by no means confines its activities to the inside of buildings, but is often found in open fields, where its depredations in shock and stack are well known.

Not only are mice and rats, especially the brown rat, a cause of destruction and damage to property, but they are also a constant menace to the health of man. It has been proved that they are the chief means of perpetuating and transmitting bubonic plague and that they play important rôles in conveying other diseases to human beings. They are parasites, without redeeming characteristics, and should everywhere be routed and destroyed.

PROTECTION OF FOOD AND OTHER STORES FROM RATS AND MICE.

Past attempts to exterminate rats and mice have failed, not so much because of lack of effective means as because of the neglect of necessary precautions and the absence of concerted endeavors. We have rendered our work abortive by continuing to provide subsistence and hiding places for the animals. If these advantages are denied, persistent and general use of the usual methods of destruction will prove far more successful.

RAT-PROOF BUILDING.

First in importance, as a measure of rat repression, is the exclusion of the animals from places where they find food and safe retreats for rearing their young.

The best way to keep rats from buildings, whether in city or in country, is to use cement in construction. As the advantages of this material are coming to be generally understood, its use is rapidly extending to all kinds of buildings. The processes of mixing and laying this material require little skill or special knowledge, and workmen of ordinary intelligence can successfully follow the plain directions contained in handbooks of cement construction.¹

Many modern public buildings are so constructed that rats can find no lodgment in the walls or foundations, and yet in a few years, through negligence, such buildings often become infested with the pests. Sometimes drain pipes are left uncovered for hours at a time. Often outer doors, especially those opening on alleys, are left ajar. A common mistake is failure to screen basement windows which must be opened for ventilation. However the intruders are admitted, when once inside they intrench themselves behind furniture or stores, and are difficult to dislodge. The addition of inner doors to vestibules is an important precaution against rats. The lower edge of outer doors to public buildings, especially markets, should be reinforced with light metal plates to prevent the animals from gnawing through. Any opening left around water, steam, or gas pipes, where they go through walls, should be closed carefully with concrete to the full depth of the wall.

Dwellings.—In constructing dwelling houses the additional cost of making the foundations rat-proof is slight compared with the advantages. The cellar walls should have concrete footings, and the walls themselves should be laid in cement mortar. The cellar floor should be of medium rather than lean concrete. Even old cellars may be made rat-proof at comparatively small expense. Rat holes may be permanently closed with a mixture of cement, sand, and broken glass, or sharp bits of crockery or stone.

¹ Farmers' Bulletin 461, Use of Concrete on the Farm, will prove useful to city and village dwellers as well as to the farmer.

On a foundation like the one described above, the walls of a wooden dwelling also may be made rat-proof. The space between the sheathing and lath, to the height of about a foot, should be filled with concrete. Rats can not then gain access to the walls, and can enter the dwelling only through doors or windows. Screening all basement and cellar windows with wire netting is a most necessary precaution.

Old buildings in cities.—Aside from old dwellings, the chief refuges for rats in cities are sewers, wharves, stables, and outbuildings. Modern sewers are used by the animals merely as highdays and not as abodes, but old-fashioned brick sewers often afford nesting crannies.



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FIG. 2.—Rat-proofing a frame dwelling by concrete side wall (United States Public Health Service, New Orleans, La., 1914).

Wharves, stables, and outbuildings in cities should be so built as to exclude rats. Cement is the chief means to this end. Old tumble-down buildings and wharves should not be tolerated in any city. (See fig. 2.)

In both city and country, wooden floors of sidewalks, areas, and porches are commonly laid upon timbers resting on the ground. Under such floors rats have a safe retreat from nearly all enemies. The conditions can be remedied in towns by municipal action requiring that these floors be replaced by others made of cement. Areas or walks made of brick are often undermined by rats and may become as objectionable as those of wood. Wooden floors of porches should always be well above the ground.

Farm buildings.—Granaries, cornercribs, and poultry houses may be made rat-proof by a liberal use of cement in the foundations and floors; or the floors may be of wood resting upon concrete. Objection has been urged against concrete floors for horses, cattle, and poultry, because the material is too good a conductor of heat, and the health of the animals suffers from contact with these floors. In poultry houses, dry soil or sand may be used as a covering for the cement floor, and in stables a wooden floor resting on concrete is just as satisfactory so far as the exclusion of rats is concerned.

The common practice of setting cornercribs on posts with inverted pans at the top often fails to exclude rats, because the posts are not high enough to place the lower cracks of the structure beyond reach of the animals. As rats are excellent jumpers, the posts should be tall enough to prevent the animals from obtaining a foothold at any place within 3 feet of the ground. A crib built in this way, however, is not very satisfactory.

For a rat-proof crib a well-drained site should be chosen. The outer walls, laid in cement, should be sunk about 20 inches into the ground. The space within the walls should be grouted thoroughly with cement and broken stone and finished with rich concrete for a floor. Upon this the structure may be built. Even the walls of the crib may be of concrete. Corn will not mold in contact with them, provided there is good ventilation and the roof is water-tight.

However, there are cheaper ways of excluding rats from either new or old cornercribs. Rats, mice, and sparrows may be kept out effectually by the use of either an inner or an outer covering of galvanized-wire netting of half-inch mesh and heavy enough to resist the teeth of the rats. The netting in common use in screening cellar windows is suitable for covering or lining cribs. As rats can climb the netting, the entire structure must be screened, or, if sparrows are not to be excluded, the wire netting may be carried up about 3 feet from the ground, and above this a belt of sheet metal about a foot in width may be tacked to the outside of the building.

Complete working drawings for the practical rat-proof cornercrib shown in figures 3 and 4 may be obtained from the Office of Public Roads and Rural Engineering of the department.

Buildings for storing foodstuffs.—Whenever possible, stores of food for man or beast should be placed only in buildings of rat-proof construction, guarded against rodents by having all windows near the ground and all other possible means of entrance screened with netting made of No. 18 or No. 20 wire and of $\frac{1}{4}$ -inch mesh. Entrance doors should fit closely, should have the lower edges protected by wide strips of metal, and should have springs attached, to insure that they shall not be left open. Before being used for housing stores, the building should be inspected as to the manner in which water,

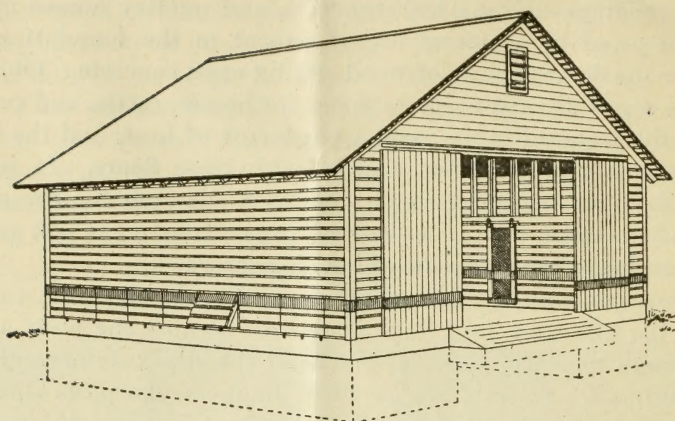


FIG. 3.—Perspective of rat-proof corncrib, showing concrete foundation by dotted lines; also belt of metal.

steam, or gas pipes go through the walls, and any openings found around such pipes should be closed with concrete.

If rat-proof buildings are not available, it is possible, by the use of concrete in basements and the other precautions just mentioned, to make an ordinary building practically safe for food storage.

When it is necessary to erect temporary wooden structures to hold forage, grain, or food supplies for army camps, the floors of such buildings should not be in contact with the ground, but elevated, the sills having a foot or more of clear space below them. Smooth posts rising 2 or 3 feet above the ground may be used for foundations, and the floor itself may be protected below by wire netting or sheet metal at all places where rats could gain a foothold. Care should be taken to have the floors as tight as possible, for it is chiefly scattered grain and fragments of food about a camp that attract rats.

Rat-proofing by elevation.—The United States Public Health Service reports that in its campaigns against bubonic plague in San Francisco (1907) and New Orleans (1914) many plague rats were found under the floors of wooden houses resting on the ground. These buildings were made rat-proof by elevation, and no case of either human or rodent plague occurred in any house after the change. Placing them on smooth posts 18 inches above the ground, with the space beneath the floor entirely open, left no hiding place for rats.

This plan is adapted to small dwellings throughout the South, and to small summer homes, temporary structures, and small farm buildings everywhere. Wherever rats might obtain a foothold on the top of the post they may be prevented from gnawing the adjacent wood by tacking metal plates or pieces of wire netting to floor or sill.

KEEPING FOOD FROM RATS AND MICE.

The effect of an abundance of food on the breeding of rodents should be kept in mind. Well-fed rats mature quickly, breed often, and have large litters. Poorly fed rats, on the contrary, reproduce less frequently and have smaller litters. In addition, scarcity of food makes measures for destroying the animals far more effective.

Merchandise in stores.—In all parts of the country there is a serious economic drain in the destruction by rats and mice of merchandise held for sale by dealers. Not only foodstuffs and forage, but textiles, clothing, and leather goods are often ruined. This loss is due mainly to the faulty buildings in which the stores are kept. Often it would be a measure of economy to tear down the old structures and replace them by new ones. However, even the old buildings may often be repaired so as to make them practically rat-proof; and foodstuffs, as flour, seeds, and meats, may always be protected in wire cages at slight expense. The public should be protected from insanitary stores by a system of rigid inspection.

Household supplies.—Similar care should be exercised in the home to protect household supplies from mice and rats. Little progress in ridding the premises of these animals can be made so long as they have access to supplies of food. Cellars, kitchens, and pantries often furnish subsistence not only to rats that inhabit the dwelling, but to many that come from outside. Food supplies may always be kept from rats and mice if placed in inexpensive rat-proof containers covered with wire netting. Sometimes all that is needed to prevent

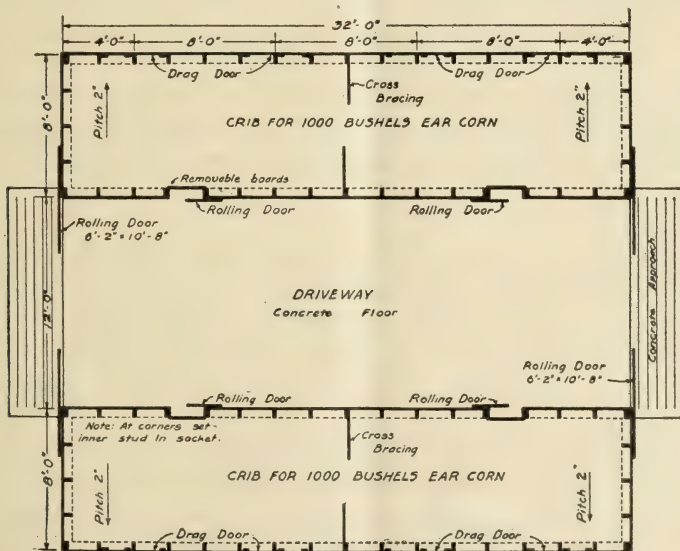


FIG. 4.—Floor plan of rat-proof corner crib shown in figure 3.

serious waste is the application of concrete to holes in the basement wall or the slight repair of a defective part of the building.

Produce in transit.—Much loss of fruits, vegetables, and other produce occurs in transit by rail and on ships. Most of the damage is done at wharves and in railway stations, but there is also considerable in ships' holds, especially to perishable produce brought from warm latitudes. Much of this may be prevented by the use of rat-proof cages at the docks, by the careful fumigation of seagoing vessels at the end of each voyage, and by the frequent fumigation of vessels in coastwise trade; but still more by replacing old and decrepit wharves and station platforms with modern ones built of concrete.

Where cargoes are being loaded or unloaded at wharves or depots, food liable to attack by rats may be temporarily safeguarded by being placed in rat-proof cages, or pounds, constructed of wire netting. Wooden boxes containing reserve food held in depots for a considerable time or intended for shipment by sea may be made rat-proof by light coverings of metal along the angles. This plan has long been in use to protect naval stores on ships and in warehouses. It is based on the fact that rats do not gnaw the plane surfaces of hard materials, but attack doors, furniture, and boxes at the angles only.

Packing houses.—Packing houses and abattoirs are often sources from which rats secure subsistence, especially where meats are prepared for market in old buildings. In old-style cooling rooms with double walls of wood and sawdust insulation, always a source of annoyance because of rat infestation, the utmost vigilance is required to prevent serious loss of meat products. On the other hand, packing houses with modern construction and sanitary devices have no trouble from rats or mice.

Garbage and waste.—Since much of the food of rats consists of garbage and other waste materials, it is not enough to bar the animals from markets, granaries, warehouses, and private food stores. Garbage and offal of all kinds must be so disposed of that rats can not obtain them.

In cities and towns an efficient system of garbage collection and disposal should be established by ordinances. Waste from markets, hotels, cafés, and households should be collected in covered metal receptacles and frequently emptied. Garbage should never be dumped in or near towns, but should be utilized or promptly destroyed by fire.

Rats find abundant food in country slaughterhouses; reform in the management of these is badly needed. Such places are centers of rat propagation. It is a common practice to leave offal of slaughtered animals to be eaten by rats and swine, and this is the chief means of perpetuating trichinæ in pork. The law should require that offal be promptly cremated or otherwise disposed of. Country slaughter-

houses should be as cleanly and as constantly inspected as abbatoirs.

Another important source of rat food is found in remnants of lunches left by employees in factories, stores, and public buildings. This food, which alone is sufficient to attract and sustain a small army of rats, is commonly left in waste baskets or other open receptacles. Strictly enforced rules requiring all remnants of food to be deposited in covered metal vessels would make trapping far more effective.

Military training camps, unless subjected to rigid discipline in the matter of disposal of garbage and waste, soon become centers of rat infestation. Waste from camps, deposited in covered metal cans and collected daily, should be removed far from the camp itself and either burned or utilized in approved modern ways.

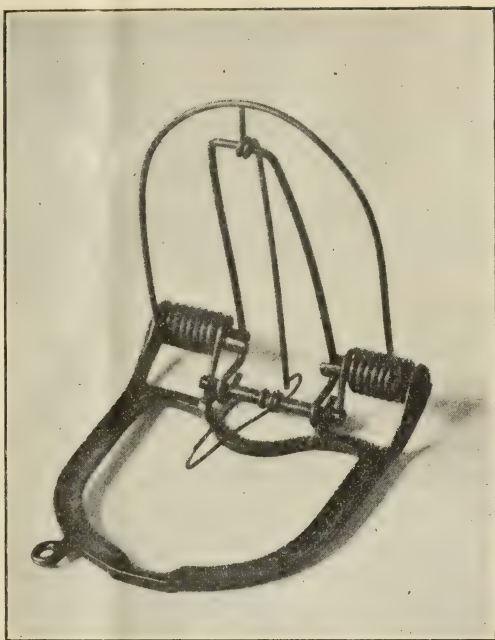


FIG. 5.—Guillotine trap made entirely of metal.

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DESTROYING RATS AND MICE.

The Biological Survey has made numerous laboratory and field experiments with various agencies for destroying rats and mice. The results form the chief basis for the following recommendations:

TRAPS.

Owing to their cunning, it is not always easy to clear rats from premises by trapping; if food is abundant, it is impossible. A few adults refuse to enter the most innocent-looking trap. And yet trapping, if persistently followed, is one of the most effective ways of destroying the animals.

Guillotine trap.—For general use the improved modern traps with a wire fall released by a baited trigger and driven by a coiled spring have marked advantages over the old forms, and many of them may be used at the same time. These traps, sometimes called “guillotine” traps, are of many designs, but the more simply constructed are preferable. Probably those made entirely of metal are the best, as they

are more durable. Traps with tin or sheet-metal bases are not recommended.

Guillotine traps of the type shown in figure 5 should be baited with small pieces of Vienna sausage (Wienerwurst) or fried bacon. A small section of an ear of corn is an excellent bait if other grain is not present. The trigger wire should be bent inward to bring the bait into proper position for the fall to strike the rat in the neck, as shown in figure 6.

Other excellent baits for rats and mice are oatmeal, toasted cheese, toasted bread (buttered), fish, fish offal, fresh liver, raw meat, pine nuts, apples, carrots, and corn, and sunflower, squash, or pumpkin seeds. Broken fresh eggs are good bait at all seasons, and ripe tomatoes, green cucumbers, and other fresh vegetables are very tempting to the animals in winter. When seed, grain, or meal is used with a guillotine trap, it is put on the trigger plate, or the trigger wire may be bent outward and the bait placed directly under it.

Oatmeal (rolled oats) is recommended as a bait for guillotine traps made with wooden base and trigger plate (fig. 7). These traps are especially convenient to use on ledges or other narrow rat runs or at the openings of rat burrows. They are often used without bait.

A common mistake in trapping for rats and mice is to use only one or two traps when dozens are needed. For a large establishment hundreds of traps may be used to advantage, and a dozen is none too many for an ordinary barn or dwelling infested with rats. House mice are less suspicious than rats and are much more easily trapped.

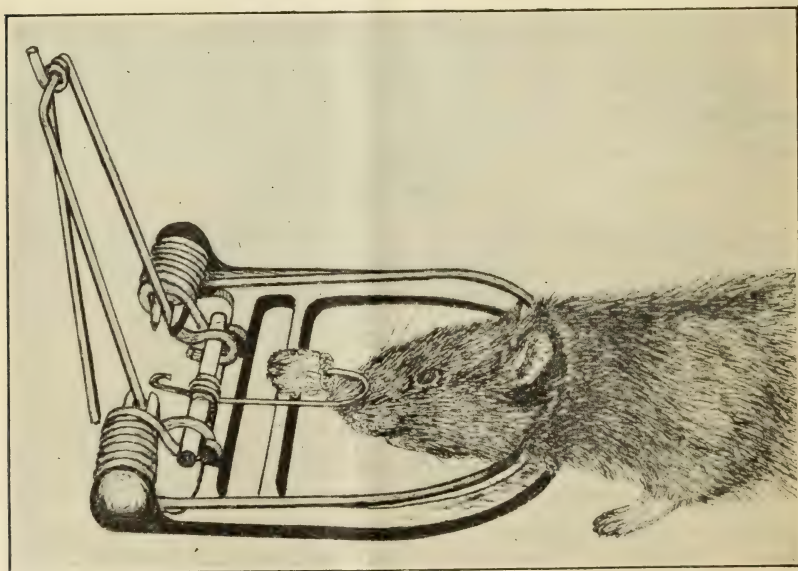


FIG. 6.—Method of baiting guillotine trap.

Small guillotine traps baited with oatmeal will soon rid an ordinary dwelling of the smaller pests.

Cage trap.—When rats are abundant, the large French wire cage traps may be used to advantage. They should be made

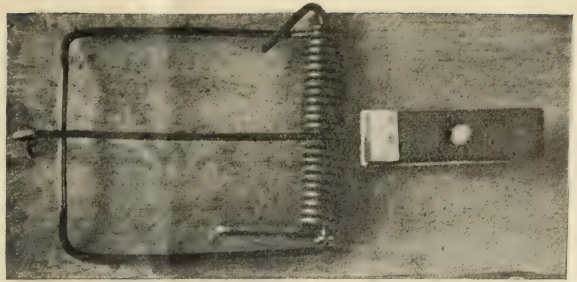


FIG. 7.—Guillotine trap with wooden base and trigger plate.

of stiff wire, well reinforced. Many of those sold in stores are useless, because a full-grown rat can bend the light wires apart and so escape.

Cage traps may be baited and left open for several nights until the rats are accustomed to enter them to obtain food. They should then be closed and freshly baited, when a larger catch may be expected, especially of young rats (fig. 8). As many as 25, and even more, partly grown rats have been taken at a time in one of these traps. It is better to cover the trap than to leave it exposed. A short board should be laid on the trap and an old cloth or bag or a bunch of hay or straw thrown carelessly over the top. Often the trap may be placed with the entrance opposite a rat hole and fitting it so closely that rats can not pass through without entering the trap. If a single rat is caught it may be left in the trap as a decoy to others.

Notwithstanding the fact that sometimes a large number of rats may be taken at a time in cage traps, a few good guillotine traps intelligently used will prove more effective in the long run.

Figure-4 trigger trap.—The old-fashioned box trap set with a figure-4 trigger is sometimes useful to secure a wise old rat that refuses to be enticed into a modern trap. Better still is a simple deadfall—



FIG. 8.—Cage trap with catch of rats.

a flat stone or a heavy plank—supported by a figure-4 trigger. An old rat will go under such a contrivance to feed without fear.

Steel trap.—The ordinary steel trap (No. 0 or 1) may sometimes be satisfactorily employed to capture a rat. The animal is usually caught by the foot, and its squealing has a tendency to frighten other rats. The trap may be set in a shallow pan or box and covered with



FIG. 9.—Barrel trap: 1, With stiff paper cover; 2, with hinged barrel cover; *a*, stop; *b*, baits.

bran or oats, care being taken to have the space under the trigger pan free of grain. This may be done by placing a very little cotton under the trigger and setting as lightly as possible. In a narrow run or at the mouth of a burrow a steel trap unbaited and covered with very light cloth or tissue paper is often effective.

The best bait usually is food of a kind that the rats and mice do not get in the vicinity. In a meat market, vegetables or grain should be used; in a feed store, meat. As far as possible food other than the bait should be inaccessible while trapping is in progress. The bait should be kept fresh and attractive, and the kind changed when necessary. Baits and traps should be handled as little as possible.

Barrel trap.—About 60 years ago a writer in the Cornhill Magazine gave details of a trap, by means of which it was claimed that 3,000 rats were caught in a warehouse in a single night. The plan involved tolling the rats to the place

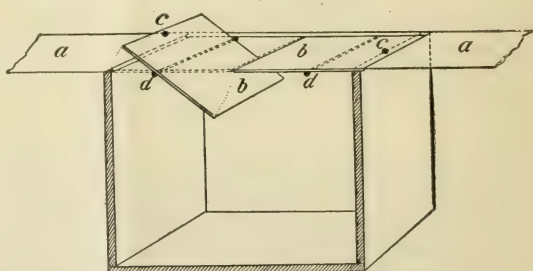


FIG. 10.—Pit trap. *aa*, Rat run; *bb*, cover; *cc*, position of weights; *dd*, rods on which covers turn.

and feeding them for several nights on the tops of barrels covered with coarse brown paper. Afterwards a cross was cut in the paper, so that the rats fell into the barrel (fig. 9 (1)). Many variations of the plan, but few improvements upon it, have been suggested by agricultural writers since that time. Reports are frequently made of large catches of rats by means of a barrel fitted with a light cover of wood, hinged on a rod so as to turn with the weight of a rat (fig. 9 (2)).

Pit trap.—A modification of the barrel trap is the pit trap (fig. 10). This consists of a stout narrow box sunk in the ground so that the top is level with the rat run. It is fixed with a cover of light wood or metal in two sections, the sections fitting nicely inside the box and working independently. They turn on rods, to which they are fastened. They are weighted near the ends of the box and so adjusted that they swing easily. An animal stepping upon the cover beyond the rods is precipitated into the box, while the cover immediately swings back to its place. Besides rats, the trap is well adapted to capture larger animals, as minks, raccoons, opossums, and cats. It is especially useful to protect poultry yards, game preserves, and the like. The trap should be placed along the fence outside the yard, and behind a shelter of boards or brush that leans against the fence.

Fence and battue.—In the rice fields of the Far East the natives build numerous piles of brush and rice straw, and leave them for several days until many rats have taken shelter in them. A portable bamboo inclosure several feet in height is then set up around each pile in succession and the straw and brush are thrown out over the top, while dogs and men kill the trapped rodents. Large numbers are destroyed in this way, and the plan with modifications may be utilized in America with satisfactory results. A wire netting of fine mesh may be used for the inclosure. The scheme is applicable at the removal of grain, straw, or haystacks, as well as brush piles.

In a large barn near Washington, a few years ago, piles of unhusked corn were left in the loft and were soon infested with rats. A wooden pen was set down surrounding the piles in turn and the corn thrown out until dogs were able to get at the rats. In this way several men and dogs killed 500 rats in a single day.

POISONS.

While the use of poison is the best and quickest way to get rid of rats and mice, the odor from the dead animals makes the method impracticable in occupied houses. Poisons may be effectively used in barns, stables, sheds, cribs, and other outbuildings.

Caution.—In the United States there are few laws which prohibit the laying of poisons on lands owned or controlled by the poisoner. Hence it is all the more necessary to exercise extreme caution to prevent accidents. In several States notice of intention to lay poison must be given to persons living in the neighborhood. Poison for rats should never be placed in open or unsheltered places. This applies particularly to strychnin or arsenic on meat. *Packages containing poisons should always bear a warning label and should not be kept where children might reach them.*

Among the principal poisons that have been recommended for killing rats and mice are barium carbonate, strychnin, arsenic, phosphorus, and squills.

Barium carbonate.—One of the cheapest and most effective poisons for rats and mice is barium carbonate. This mineral has the advantage of being without taste or smell. It has a corrosive action on the mucous lining of the stomach and is dangerous to larger animals if taken in sufficient quantity. In the small doses fed to rats and mice it would be harmless to domestic animals. Its action upon rats is slow, and if exit is possible the animals usually leave the premises in search of water. For this reason the poison may frequently, though not always, be used in houses without disagreeable consequences.

Barium carbonate may be fed in the form of dough composed of four parts of meal or flour and one part of the mineral. A more convenient bait is ordinary oatmeal with about one-eighth of its bulk of the mineral, mixed with water into a stiff dough. A third plan is to spread the barium carbonate upon fish, toasted bread (moistened), or ordinary bread and butter. The prepared bait should be placed in rat runs, about a teaspoonful at a place. If a single application of the poison fails to kill or drive away all rats from the premises, it should be repeated with a change of bait.

Strychnin.—Strychnin is too rapid in action to make its use for rats desirable in houses, but elsewhere it may be employed effectively. Strychnia sulphate is the best form to use. The dry crystals may be inserted in small pieces of raw meat, Vienna sausage, or toasted cheese, and these placed in rat runs or burrows; or oatmeal may be moistened with a strychnin sirup and small quantities laid in the same way.

Strychnin sirup is prepared as follows: Dissolve a half ounce of strychnia sulphate in a pint of boiling water; add a pint of thick sugar sirup and stir thoroughly. A smaller quantity may be prepared with a proportional quantity of water and sirup. In preparing the bait it is necessary to moisten all the oatmeal with the sirup. Wheat and corn are excellent alternative baits. The grain should be soaked overnight in the strychnin sirup.

Arsenic.—Arsenic is probably the most popular of the rat poisons, owing to its cheapness, yet our experiments prove that, measured by the results obtained, arsenic is dearer than strychnin. Besides, arsenic is extremely variable in its effect upon rats, and if the animals survive a first dose it is very difficult to induce them to take another.

Powdered white arsenic (arsenious acid) may be fed to rats in almost any of the baits mentioned under barium carbonate and strychnin. It has been used successfully when rubbed into fresh fish or spread on buttered toast. Another method is to mix twelve

parts by weight of corn meal and one part of arsenic with whites of eggs into a stiff dough.

An old formula for poisoning rats and mice with arsenic is the following, adapted from an English source:

Take a pound of oatmeal, a pound of coarse brown sugar, and a spoonful of arsenic. Mix well together and put the composition into an earthen jar. Put a tablespoonful at a place in runs frequented by rats.

Phosphorus.—For poisoning rats and mice, phosphorus is used almost as commonly as arsenic, and undoubtedly it is effective when given in an attractive bait. The phosphorus paste of the drug stores is usually dissolved yellow phosphorus, mixed with glucose or other substances. The proportion of phosphorus varies from one-fourth of 1 per cent to 4 per cent. The first amount is too small to be always effective and the last is dangerously inflammable. When homemade preparations of phosphorus are used there is much danger of burning the person or of setting fire to crops or buildings. In the Western States many fires have resulted from putting out homemade phosphorus poisons for ground squirrels, and entire fields of ripe grain have been destroyed in this way. Even with commercial pastes the action of sun and rain changes the phosphorus and leaches out the glucose until a highly inflammable residue is left.

It is often claimed that phosphorus eaten by rats or mice dries up or mummifies the body so that no odor results. The statement has no foundation in fact. No known poison will prevent decomposition of the body of an animal that died from its effects. Equally misleading is the statement that rats poisoned with phosphorus do not die on the premises. Owing to its slower operation, no doubt a larger portion escape into the open before dying than when strychnin is used.

The Biological Survey does not recommend the use of phosphorus as a poison for rodents.

Squills.—The squill, or sea leek,¹ is a favorite rat poison in many parts of Europe and is well worthy of trial in America. It is rapid and very deadly in its action, and rats seem to eat it readily. The poison is used in several ways. Two ounces of dry squills, powdered, may be thoroughly mixed with eight ounces of toasted cheese or of butter and meal and put out in runs of rats or mice. Another formula recommends two parts of squills to three parts of finely chopped bacon, mixed with meal enough to make it cohere. This is baked in small cakes.

Poison in poultry houses.—For poisoning rats in buildings and yards occupied by poultry the following method is recommended: Two

¹ *Scilla maritima*.

wooden boxes should be used, one considerably larger than the other and each having one or more holes in the sides large enough to admit rats. The poisoned bait should be placed on the bottom and near the middle of the smaller box, and the larger box should then be inverted over it. Rats thus have free access to the bait, but fowls are excluded.

DOMESTIC ANIMALS.

Among domestic animals employed to kill rats are the dog, the cat, and the ferret.

Dogs.—The value of dogs as ratters can not be appreciated by persons who have had no experience with a trained animal. The ordinary cur and the larger breeds of dogs seldom develop the necessary qualities for ratters. Small Irish, Scotch, and fox terriers, when properly trained, are superior to other breeds and under favorable circumstances may be relied upon to keep the farm premises reasonably free from rats.

Cats.—However valuable cats may be as mousers, few learn to catch rats. The ordinary house cat is too well fed and consequently too lazy to undertake the capture of an animal as formidable as the brown rat. Birds and mice are much more to its liking. Cats that are fearless of rats, however, and have learned to hunt and destroy them are often very useful about stables and warehouses. They should be lightly fed, chiefly on milk. A little sulphur in the milk at intervals is a corrective against the bad effects of a constant rat or mouse diet. Cats often die from eating these rodents.

Ferrets.—Tame ferrets, like weasels, are inveterate foes of rats, and can follow the rodents into their retreats. Under favorable circumstances they are useful aids to the rat catcher, but their value is greatly overestimated. For effective work they require experienced handling and the additional services of a dog or two. Dogs and ferrets must be thoroughly accustomed to each other, and the former must be quiet and steady instead of noisy and excitable. The ferret is used only to bolt the rats, which are killed by the dogs. If unmuzzled ferrets are sent into rat retreats, they are apt to make a kill and then lie up after sucking the blood of their victim. Sometimes they remain for hours in the burrows or escape by other exits and are lost. There is danger that these lost ferrets may adapt themselves to wild conditions and become a pest by preying upon poultry and birds.

FUMIGATION.

Rats may be destroyed in their burrows in the fields and along river banks, levees, and dikes by carbon bisulphid.¹ A wad of cot-

¹ CAUTION.—Carbon disulphid is very inflammable and can be ignited by a match, lantern, cigar, or pipe.

ton or other absorbent material is saturated with the liquid and then pushed into the burrow, the opening being packed with earth to prevent the escape of the gas. All animals in the burrow are asphyxiated. Fumigation in buildings is not so satisfactory, because it is difficult to confine the gases. Moreover, when effective, the odor from the dead rats is highly objectionable in occupied buildings.

Chlorin, carbon monoxid, sulphur dioxid, and hydrocyanic acid are the gases most used for destroying rats and mice in sheds, warehouses, and stores. Each is effective if the gas can be confined and made to reach the retreats of the animals. Owing to the great danger from fire incident to burning charcoal or sulphur in open pans, a special furnace provided with means for forcing the gas into the compartments of vessels or buildings is generally employed.

Hydrocyanic-acid gas is effective in destroying all animal life in buildings. It has been successfully used to free elevators and warehouses of rats, mice, and insects. However, it is so dangerous to human life that the novice should not attempt fumigation with it, except under careful instructions. Directions for preparing and using the gas may be found in a publication entitled *Hydrocyanic-acid Gas against Household Insects*, by Dr. L. O. Howard and Charles H. Popenoe.¹

Carbon monoxid is rather dangerous, as its presence in the hold of a vessel or other compartment is not manifest to the senses, and fatal accidents have occurred during its employment to fumigate vessels.

Chlorin gas has a strong bleaching action upon textile fabrics, and for this reason can not be used in many situations.

Sulphur dioxid also has a bleaching effect upon textiles, but less marked than that of chlorin, and ordinarily it is not noticeable with the small percentage of the gas it is necessary to use. On the whole, this gas has many advantages as a fumigator and disinfectant. It is used also as a fire extinguisher on board vessels. Special furnaces for generating the gas and forcing it into the compartments of ships and buildings are on the market, and many steamships and docks are now fitted with the necessary apparatus.

RAT VIRUSES.

Several microorganisms, or bacteria, found originally in diseased rats or mice, have been exploited for destroying rats. A number of these so-called rat viruses are on the American market. The Biological Survey, the Bureau of Animal Industry, and the United States Public Health Service have made careful investigations and practical tests of these viruses, mostly with negative results. The cultures tested by the Biological Survey have not proved satisfactory.

The chief defects to be overcome before the cultures can be recommended for general use are:

¹ Farmers' Bulletin 699.

1. The virulence is not great enough to kill a sufficiently high percentage of rats that eat food containing the microorganisms.

2. The virulence decreases with the age of the cultures. They deteriorate in warm weather and in bright sunlight.

3. The diseases resulting from the microorganisms are not contagious and do not spread by contact of diseased with healthy animals.

4. The comparative cost of the cultures is too great for general use. Since they have no advantages over the common poisons, except that they are usually harmless to man and other animals, they should be equally cheap; but their actual cost is much greater. Moreover, considering the skill and care necessary in their preparation, it is doubtful if the cost can be greatly reduced.

The Department of Agriculture, therefore, does not prepare, use, or recommend the use of rat viruses.

NATURAL ENEMIES OF RATS AND MICE.

Among the natural enemies of rats and mice are the larger hawks and owls, skunks, foxes, coyotes, weasels, minks, dogs, cats, and ferrets.

Probably the greatest factor in the increase of rats, mice, and other destructive rodents in the United States has been the persistent killing off of the birds and mammals that prey upon them. Animals that on the whole are decidedly beneficial, since they subsist upon harmful insects and rodents, are habitually destroyed by some farmers and sportsmen because they occasionally kill a chicken or a game bird.

The value of carnivorous mammals and the larger birds of prey in destroying rats and mice should be more fully recognized, especially by the farmer and the game preserver. Rats actually destroy more poultry and game, both eggs and young chicks, than all the birds and wild mammals combined; yet some of their enemies among our most useful birds of prey and carnivorous mammals are persecuted almost to the point of extinction. An enlightened public sentiment should cause the repeal of all bounties on these animals and afford protection to the majority of them.

ORGANIZED EFFORTS TO DESTROY RATS.

The necessity of cooperation and organization in the work of rat destruction is of the utmost importance. To destroy all the animals on the premises of a single farmer in a community has little permanent value, since they are soon replaced from near-by farms. If, however, the farmers of an entire township or county unite in efforts to get rid of rats, much more lasting results may be attained. If continued from year to year, such organized efforts are very effective.

COMMUNITY EFFORTS.

Coöperative efforts to destroy rats have taken various forms in different localities. In cities, municipal employees have occasionally been set at work hunting rats from their retreats, with at least temporary benefit to the community. Thus, in 1904, at Folkestone, England, a town of about 25,000 inhabitants, the corporation employees, helped by dogs, in three days killed 1,645 rats.

Side hunts in which rats are the only animals that count in the contest have sometimes been organized and successfully carried out. At New Burlington, Ohio, a rat hunt took place some years ago in which each of the two sides killed over 8,000 rats, the beaten party serving a banquet to the winners.

There is danger that organized rat hunts will be followed by long intervals of indifference and inaction. This may be prevented by offering prizes covering a definite period of effort. Such prizes accomplish more than municipal bounties, because they secure a friendly rivalry which stimulates the contestants to do their utmost to win.

In England and some of its colonies contests for prizes have been organized to promote the destruction of the English, or house, sparrow, but many of the so-called sparrow clubs are really sparrow and rat clubs, for the destruction of both pests is the avowed object of the organizations. A sparrow club in Kent, England, accomplished the destruction of 28,000 sparrows and 16,000 rats in three seasons by the annual expenditure of but £6 (\$29.20) in prize money. Had ordinary bounties been paid for this destruction, the tax on the community would have been about £250 (over \$1,200).

Many organizations already formed should be interested in destroying rats. Boards of trade, civic societies, and citizens' associations in towns and farmers' and women's clubs in rural communities will find the subject of great importance. Women's municipal leagues in several large cities already have taken up the matter. The league in Baltimore recently secured appropriations of funds for expenditure in fighting mosquitoes, flies, and rats. The league in Boston during the past year, supported by voluntary contributions for the purpose, made a highly creditable educational campaign against rats. Boys' corn clubs, the troops of Boy Scouts, and similar organizations could do excellent work in rat campaigns.

STATE AND NATIONAL AID.

To secure permanent results any general campaign for the elimination of rats must aim at *building the animals out of shelter and food*. Building reforms depend on municipal ordinances and legislative

enactments. The recent plague eradication work of the United States Public Health Service in San Francisco, Seattle, New Orleans, and at various places in Hawaii and Porto Rico required such ordinances and laws as well as financial aid in prosecuting the work. The campaign of Danish and Swedish organizations for the destruction of rats had the help of governmental appropriations. The legislatures of California, Texas, Indiana, and Hawaii have in recent years passed laws or made appropriations to aid in rat riddance. It is probable that well-organized efforts of communities would soon win legislative support everywhere. Communities should not postpone efforts, however, while waiting for legislative cooperation, but should at once organize and begin repressive operations. Wherever health is threatened the Public Health Service of the United States can cooperate, and where crops and other products are endangered the Bureau of Biological Survey of the Department of Agriculture is ready to assist by advice and in demonstration of methods.

IMPORTANT REPRESSIVE MEASURES.

The measures needed for repressing and eliminating rats and mice include the following:

1. The requirement that all new buildings erected shall be made rat-proof under competent inspection.

2. That all existing rat-proof buildings shall be closed against rats and mice by having all openings accessible to the animals, from foundation to roof, closed or screened by door, window, grating, or meshed wire netting.

3. That all buildings not of rat-proof construction shall be made so by remodeling, by the use of materials that may not be pierced by rats, or by elevation.

4. The protection of our native hawks, owls, and smaller predatory mammals—the natural enemies of rats.

5. Greater cleanliness about markets, grocery stores, warehouses, courts, alleys, stables, and vacant lots in cities and villages, and like care on farms and suburban premises. This includes the storage of waste and garbage in tightly covered vessels and the prompt disposal of it each day.

6. Care in the construction of drains and sewers, so as not to provide entrance and retreat for rats. Old brick sewers in cities should be replaced by concrete or tile.

7. The early threshing and marketing of grains on farms, so that stacks and mows shall not furnish harborage and food for rats.

8. Removal of outlying straw stacks and piles of trash or lumber that harbor rats in fields and vacant lots.

9. The keeping of provisions, seed grain, and foodstuffs in rat-proof containers.

10. Keeping effective rat dogs, especially on farms and in city warehouses.

11. The systematic destruction of rats, whenever and wherever possible, by (*a*) trapping, (*b*) poisoning, and (*c*) organized hunts.

12. The organization of clubs and other societies for systematic warfare against rats.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO NOXIOUS MAMMALS.

AVAILABLE FOR FREE DISTRIBUTION.

- How to Destroy Rats. (Farmers' Bulletin 369.)
The Common Mole of Eastern United States. (Farmers' Bulletin 583.)
Field Mice as Farm and Orchard Pests. (Farmers' Bulletin 670.)
Cottontail Rabbits in Relation to Trees and Farm Crops. (Farmers' Bulletin 702.)
Trapping Moles and Utilizing Their Skins. (Farmers' Bulletin 832.)
Destroying Rodent Pests on the Farm. (Separate 708, Yearbook for 1916.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

- Harmful and Beneficial Mammals of the Arid Interior, with Special Reference to the Carson and Humboldt Valleys, Nevada. (Farmers' Bulletin 335.) Price 5 cents.
The Nevada Mouse Plague of 1907-8. (Farmers' Bulletin 352.) Price 5 cents.
Some Common Mammals of Western Montana in Relation to Agriculture and Spotted Fever. (Farmers' Bulletin 484.) Price 5 cents.
Danger of Introducing Noxious Animals and Birds. (Separate 132, Yearbook 1898.) Price 5 cents.
Meadow Mice in Relation to Agriculture and Horticulture. (Separate 388, Yearbook 1905.) Price 5 cents.
Mouse Plagues, Their Control and Prevention. (Separate 482, Yearbook 1908.) Price — cents.
Use of Poisons for Destroying Noxious Mammals. (Separate 491, Yearbook 1908.) Price 5 cents.
Pocket Gophers as Enemies of Trees. (Separate 506, Yearbook 1909.) Price 5 cents.
The Jack Rabbits of the United States. (Biological Survey Bulletin 8.) Price 10 cents.
Economic Study of Field Mice, genus *Microtus*. (Biological Survey Bulletin 31.) Price 15 cents.
The Brown Rat in the United States. (Biological Survey Bulletin 33.) Price 15 cents.
Directions for the Destruction of Wolves and Coyotes. (Biological Survey Circular 55.) Price 5 cents.
The California Ground Squirrel. (Biological Survey Circular 76.) Price 5 cents.
Seed-eating Mammals in Relation to Reforestation. (Biological Survey Circular 78.) Price 5 cents.
Mammals of Bitterroot Valley, Montana, in Their Relation to Spotted Fever. (Biological Survey Circular 82.) Price 5 cents.

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